# Human Space Flight Architecture Team (HAT) Overview

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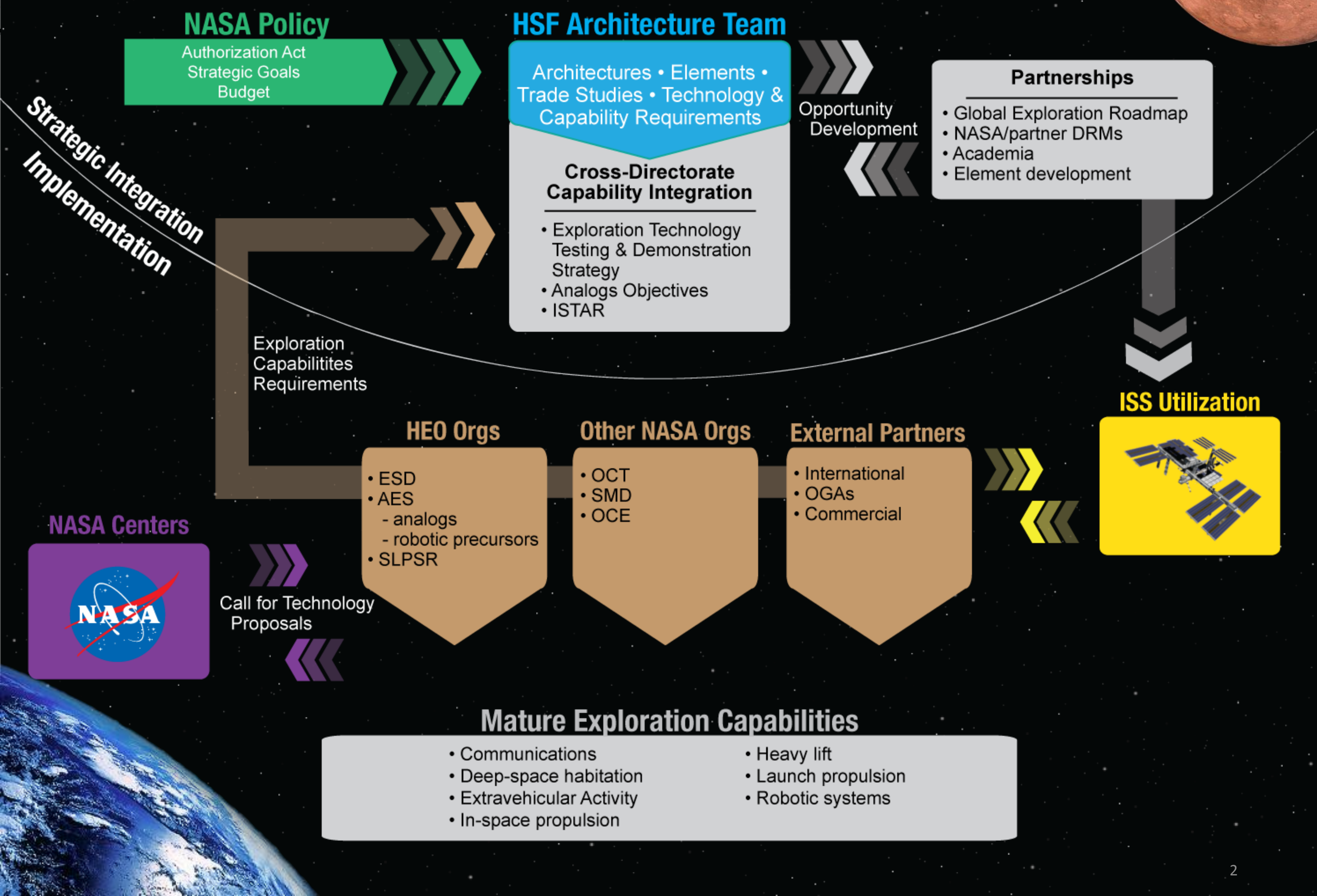
NASA/Johnson Space Center

GER Workshop, November 2011

# Exploration Capability Development and Testing

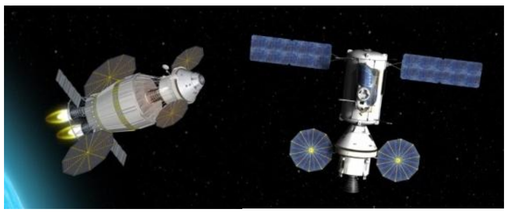


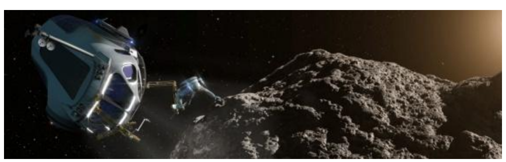
# NASA's Human Spaceflight Architecture Team (HAT)

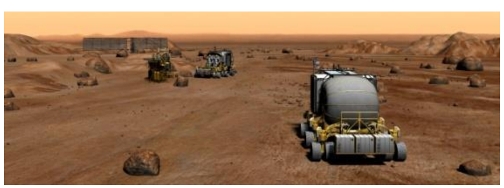
- **Multi-disciplinary, cross-agency study team that conducts strategic analysis cycles to assess integrated development approaches for architectures, systems, mission scenarios, and concepts of operation for human and robotic space exploration.**
  - During each analysis cycle, HAT iterates and refines design reference mission (DRM) definitions to inform integrated, capability-driven approaches for systems planning within a multi-destination framework.
- **Sample Activities in 2011 – Cycles A, B, C**
  - Prepared Design Reference Missions that frame key driving requirements for SLS & MPCV
  - Developed technical content & mission definitions for discussion with the international community developing the Global Exploration Roadmap
  - Advanced Capability Driven Framework concept including more extended reviews of both capabilities needed and development options.
  - Provided technical links between Capability Driven Framework and level 1 requirements for MPCV and SLS

# Primary Transportation DRMs

***Select destinations used to drive transportation systems requirements and assess impacts of changes in mission assumptions***







| Proposed Status | ISECG | DRM ID | DRM Title | Dest. |
|---|---|---|---|---|
| Cycle-C | N | LEO_UTL_2A | LEO Utilization - Non-ISS | LEO |
| | | | | |
| Cycle-C | Y | CIS_LP1_1A | Lunar Vicinity - EM L-1 | E-M L1 |
| Cycle-C | Y | CIS_LP1_1B | Lunar Vicinity - EM L-1 DSH Delivery | E-M L1 |
| Cycle-C | Y | CIS_LP1_1C | Lunar Vicinity - EM L-1 with Pre-deployed DSH | E-M L1 |
| Cycle-C | Y | CIS_LLO_1A | Low Lunar Orbit | LLO |
| | | | | |
| Cycle-C | Y | LUN_SOR_1A | Lunar Surface Polar Access - LOR/LOR | Moon |
| Cycle-C | Y | LUN_CRG_1A | Lunar Surface Cargo Mission | Moon |
| | | | | |
| Cycle-C | N | NEA_MIN_1A | Minimum Capability, Low Energy NEA | NEA |
| Cycle-C | Y | NEA_MIN_1B | Minimum Capability, Low Energy NEA with Pre-deployed DSH | NEA |
| Cycle-C | N | NEA_MIN_2A | Minimum Capability, High Energy NEA | NEA |
| Cycle-C | N | NEA_FUL_1A | Full Capability, High Energy NEA with SEP | NEA |
| Cycle-C | Y | NEA_FUL_1B | Full Capability, High Energy NEA with SEP and pre-deployed DSH | NEA |
| | | | | |
| Forward Work | N | MAR_PHD_1A | Martian Moon: Phobos/Deimos | Mars Moon |
| Forward Work | N | MAR_SFC_1A | Mars Landing | Mars Surface |

# Evolution of Key Assumptions that Drive Transportation System Performance

HEFT → Cycle-A → Cycle-B → Cycle-C

## HEFT

- **10% Architecture Reserve**
  - on wet cargo stack (+ adapter) mass
- **2.5% launch vehicle adapter mass**
  - on wet cargo stack mass
- **1% Flight Performance Reserve (FPR) on ΔVs**
- **Elements Margins**
  - MPCV: data provided
  - Other elements: 30% MGA
- **Insertion orbit:**
  - 55.56 x 240.76 km
- **Crew of 3 on Lunar & NEA missions**
- **25 meter SLS shroud barrel**

## Cycle-A

- **5% Level I Customer Reserve**
  - on wet cargo stack (+ adapter) mass
- **2.5% launch vehicle adapter mass**
  - on wet cargo stack mass
- **5% Flight Performance Reserve (FPR) on ΔVs**
- **Elements Margins**
  - MPCV: data provided
  - CPS BLK1: 15%
  - Other elements: 30% MGA
- **Insertion orbit:**
  - 55.56 x 240.76 km
- **Crew of 3 on Lunar & NEA missions**
- **25 meter SLS shroud barrel**

## Cycle-B

- **5% Level I Customer Reserve**
  - on wet cargo stack (+ adapter) mass
- **2.5% launch vehicle adapter mass**
  - on wet cargo stack mass
- **5% Flight Performance Reserve (FPR) on ΔVs**
- **Elements Margins (Derived from AIAA Standards)**
  - MPCV: data provided
  - Other elements: 30% MGA
- **Insertion orbit:**
  - -87 km X 241 km
- **Crew of 4 on Lunar & NEA missions**
- **18 meter SLS shroud barrel**

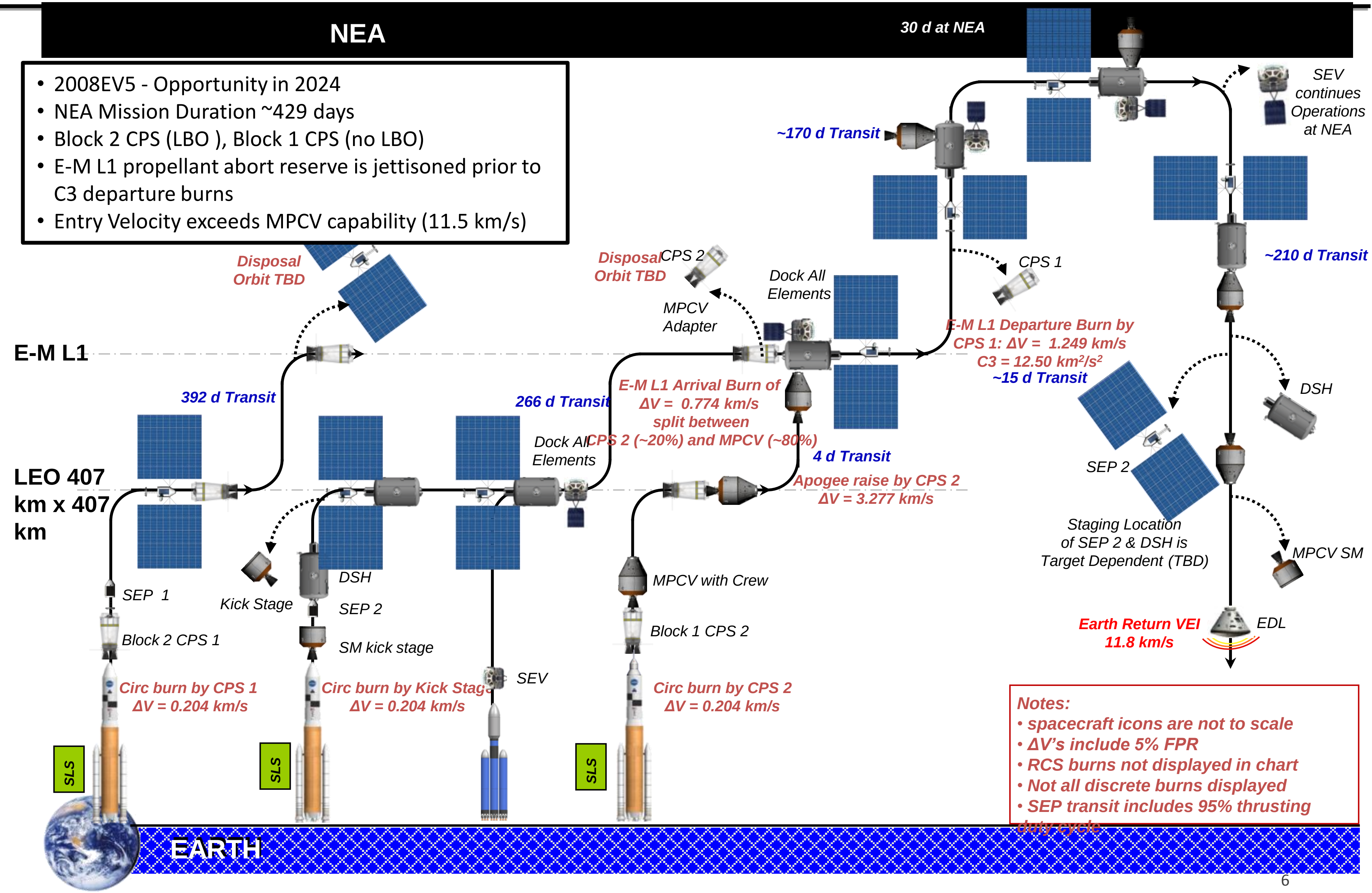
## Cycle-C

- **5% Level I Customer Reserve**
  - on wet cargo stack (+ adapter) mass
- **2.5% launch vehicle adapter mass**
  - on wet cargo stack mass
- **5% Flight Performance Reserve (FPR) on ΔVs**
  - Except for MPCV burns
- **Elements Margins (Derived from AIAA Standards)**
  - MPCV : data provided
  - CPS: BLK1 - 18.8%, BLK 2- 21.2%
  - Lander: Margin remains on lunar surface
  - Other elements: 30% MGA
- **Insertion orbit:**
  - -87 km X 241 km
- **Crew of 4 on Lunar & NEA missions**
- **18 meter SLS shroud barrel**

# Full Capability, High Energy NEA (2008EV5) with SEP

## NEA_FUL_1A_C11B1

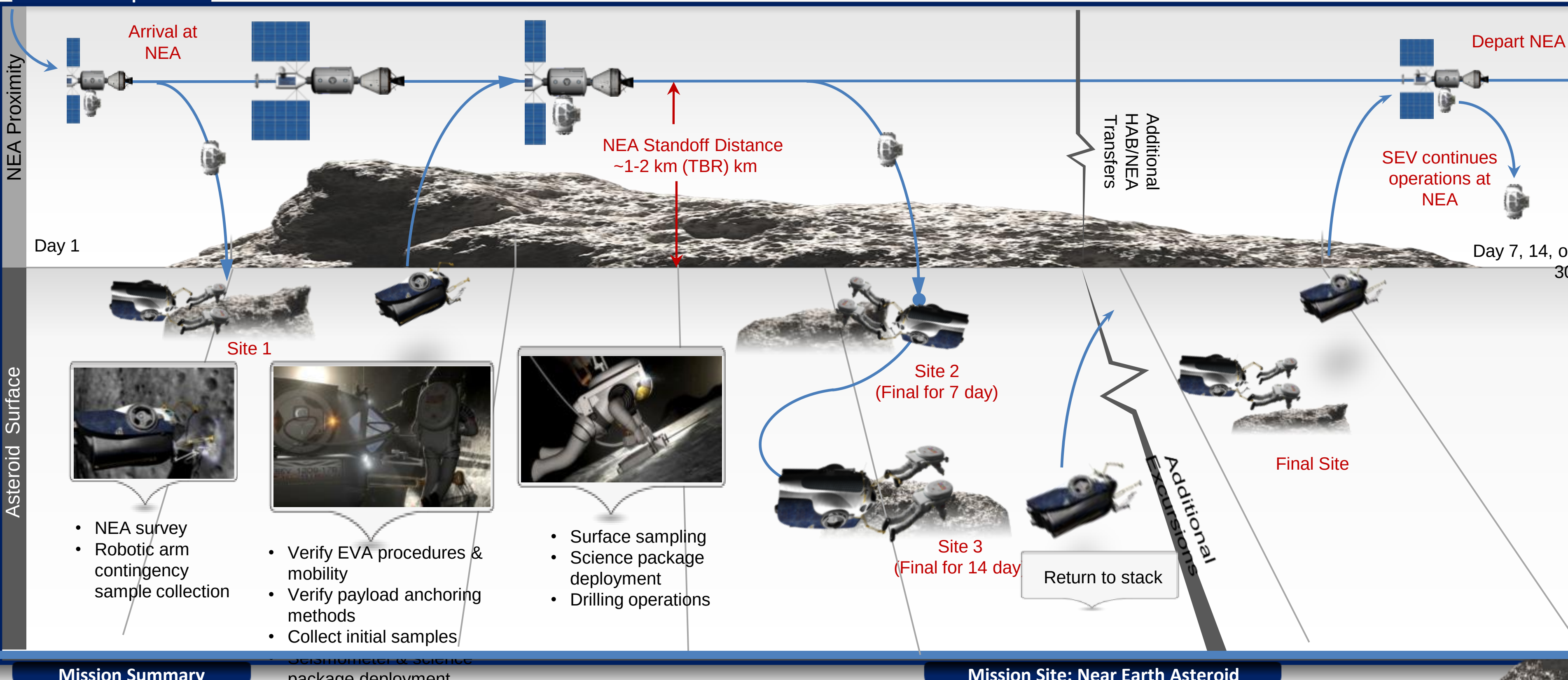
- 2008EV5 - Opportunity in 2024
- NEA Mission Duration ~429 days
- Block 2 CPS (LBO ), Block 1 CPS (no LBO)
- E-M L1 propellant abort reserve is jettisoned prior to C3 departure burns
- Entry Velocity exceeds MPCV capability (11.5 km/s)




Notes:
- spacecraft icons are not to scale
- ΔV's include 5% FPR
- RCS burns not displayed in chart
- Not all discrete burns displayed
- SEP transit includes 95% thrusting duty cycle

# NEA Exploration - Single SEV Option; 7, 14 or 30 days at NEA

## Mission Sequence




## Mission Summary

SEV robotic arms anchor to the NEA surface and provide astronaut platforms during EVA. The mother-ship stack, including the SEP, DSH, and MPCV, stationkeeps at a safe standoff distance. Surface activities include sample collection and deployment of probes (radar, acoustic, seismometer, etc.), experiments and planetary defense devices.

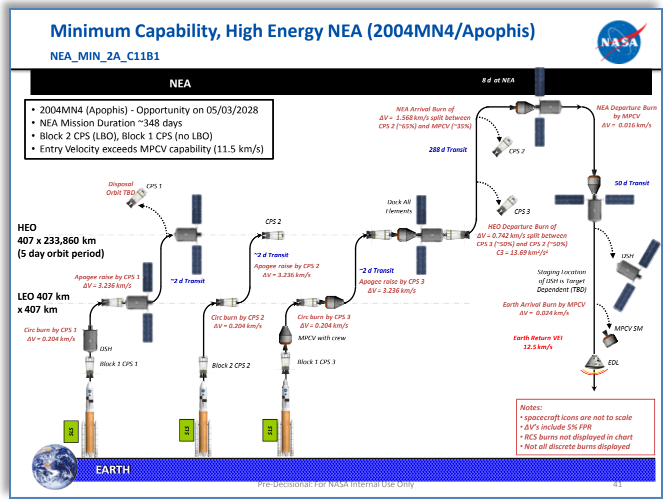
| Mission Activities | 7 Day | 14 Day | 30 Day |
|---|---|---|---|
| Number of deployed equipment packages | 4 | 10 | 24 |
| Total EVA hours | 48 | 96 | 192 |
| Number of sites visited | 2 | 3 | 6 |
| Total Est. Mass (kg) delivered/returned | tbd/tbd | tbd/tbd | tbd/tbd |

## Mission Site: Near Earth Asteroid

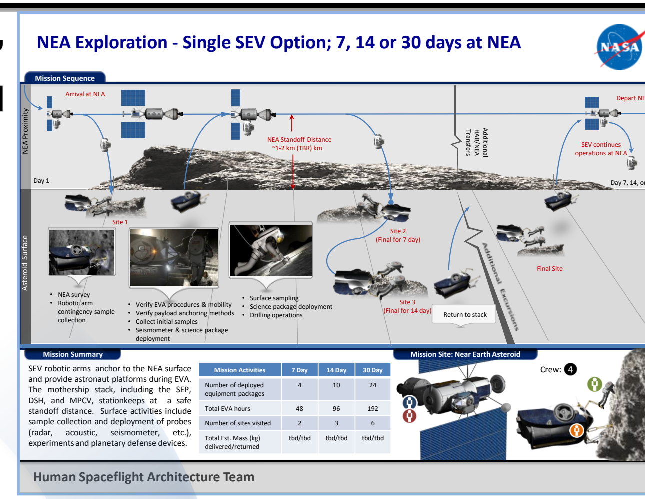
# HAT Cycle C Updates

- **Cycle C work by the HAT team continued to refine the DRMs to improve both consistency and technical feasibility. Some key changes:**
  - Direct injection to destination when possible
    - Removed circularization burn to 407 km x 407 km where applicable
  - Clarified boil-off requirements and identified usable propellant and dry mass of propellant units separately
  - Continued to add depth to the definition of human activities while at destinations
  - Developed and utilized consistent operational timeline assumptions
    - See back-up for assumptions
  - Improved consistency of margin analysis for many elements and phases, such as MPCV propulsive burns
  - Resolved station keeping problems
    - Deep Space Hab always attached to another element for ACS/RCS
  - Shifted DRMs between primary and supporting, added new DRMs to primary
    - To improve alignment with programmatic activities in preparation for on-going SRR

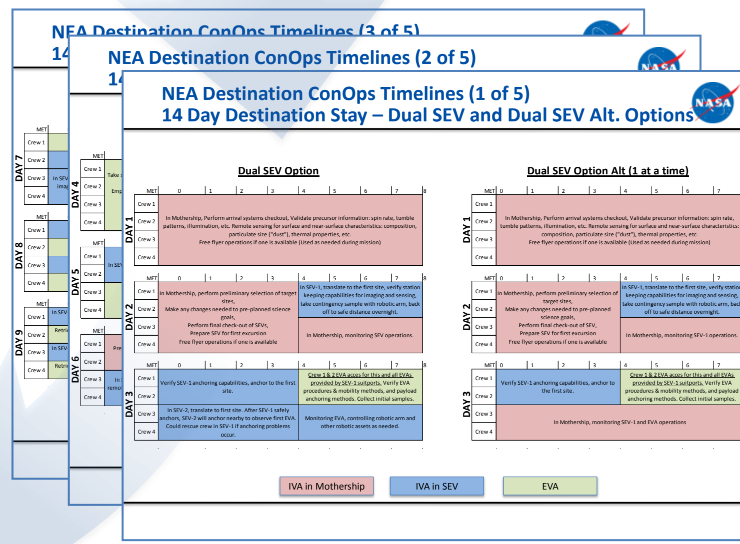
# Destination Products



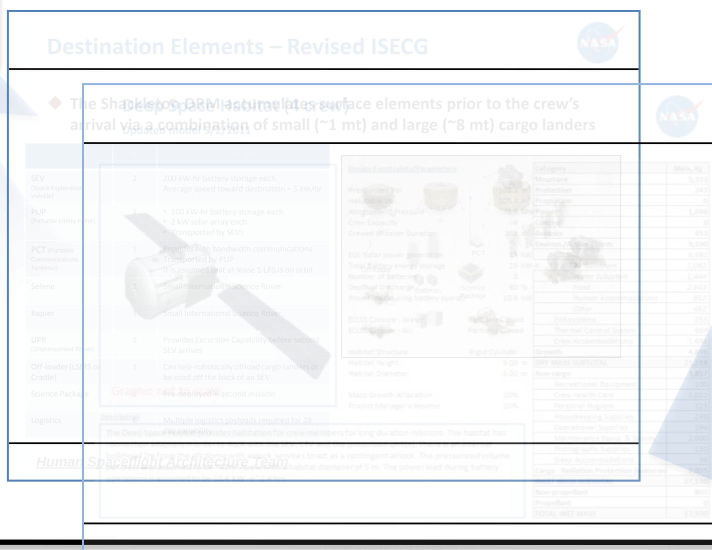

“Street View”
Destination DRM




Ops Con/
Ops Timeline




*Feedback to Transportation DRMs*

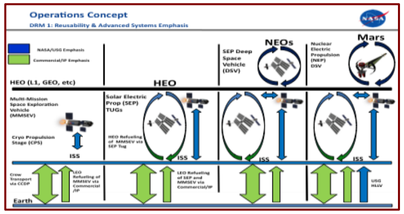



Destination
Elements
“Baseball
Cards”

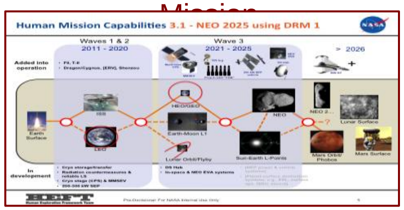
# Informing Exploration: Strategic Knowledge Gaps

- **To inform mission/system planning and design *and* near-term Agency investments**
  - Human Spaceflight Architecture Team (HAT) Destination Leads were asked to identify the data or information needed that would reduce risk, increase effectiveness, and aid in planning and design
  - The data can be obtained on Earth, in space, by analog, experimentation, or direct measurement
- **For some destinations, the needed knowledge is well identified**
  - Analysis Groups, such as LEAG and MEPAG, have identified pertinent measurements to gain the needed knowledge regarding the Moon and Mars
  - Significant advances in filling the knowledge gaps have been made (examples: LRO and MRO, and soon, MSL)
- **The Strategic Knowledge Gaps (SKGs) identified here represent an informed and systematic look at anticipated needs**
  - Inputs and comments from other agencies are welcome in order to provide for an international discussion during the January ISECG Workshop
- **The SKGs will also form the basis for near-term NASA investments in robotic precursor missions through Announcements of Opportunity (AO), competed and secondary missions, etc.  A few examples include:**
    - New Frontiers 4 AO
    - Discovery 13 AO
    - NASA Lunar Science Institute Cooperative Agreement Notice
    - LASER (Lunar Advanced Science and Exploration Research) and SALMON (Stand Alone Missions of Opportunity Notice) calls
    - Development of early flight opportunities

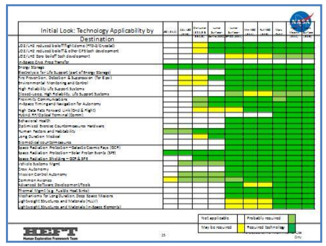
# Architecture Cost Analysis Approach



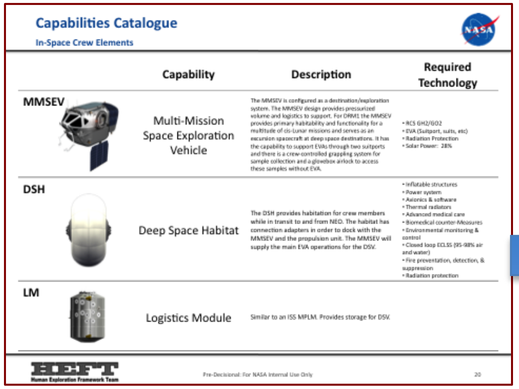

Technical Design Reference Mission



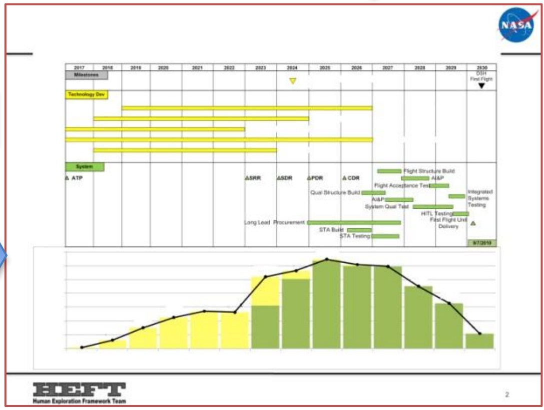

Investment strategy



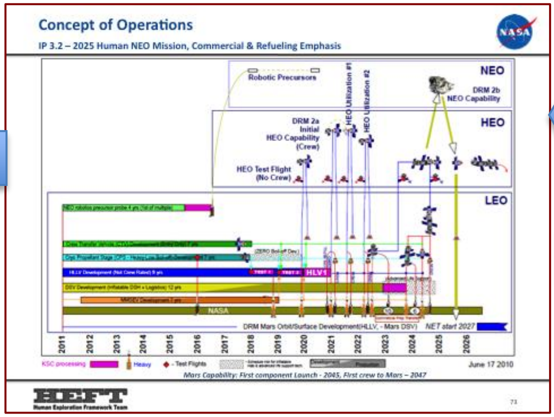
Technology Assessment



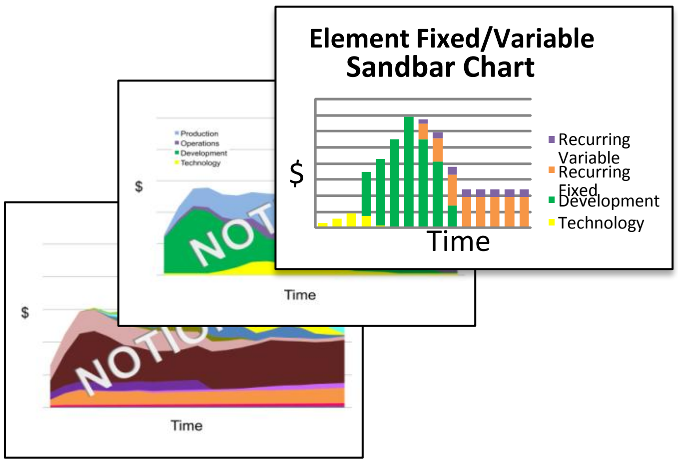

Element catalog




Schedule and cost to develop and operate each element




Integrated program schedule & flight manifest



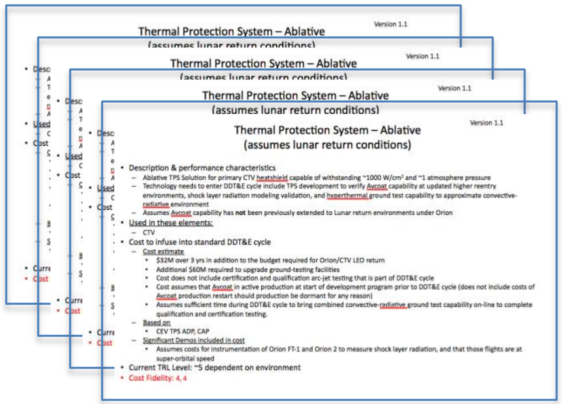

Cost Products

# Technology Development Assessment: Data Capture Process

Strategy & DRMs

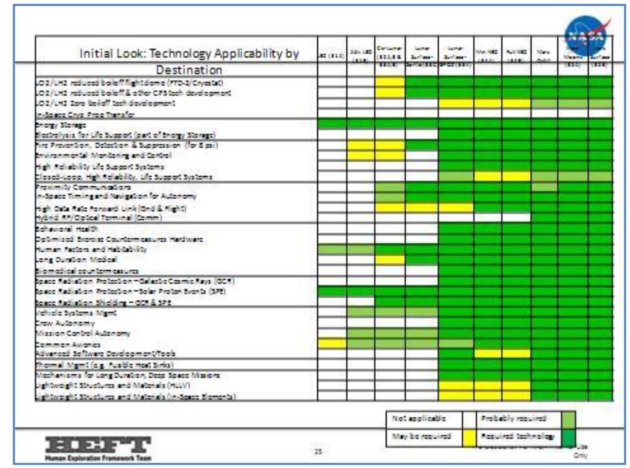
Element Data

## Tech Dev 'One-Pager' Sheets



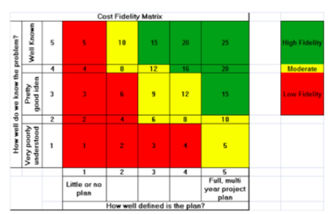

## 'Tech Dev' Summary Spreadsheet

(per Strategy/DRM)




**Subject Matter Expert POCs**
(e.g. ETDD/OCT, HRP, Element Leads, SE, etc.)

Cost Fidelity




- Tech Dev Data for HAT Cost Team:
  - Cost, Schedule, Phasing
  - Applicable Elements (per DRM)
- ETDD/OCT/HRP Data Inputs
- HEDS Data Inputs (e.g. AES priorities, Analogs, ISS demo candidates, etc.)
- ISECG Technology Dev Inputs